

Mobile Learning in Engineering Education: The Jordan Example

A.Y. Al-Zoubi¹, Sabina Jeschke² and Olivier Pfeiffer³

¹ Princess Sumaya University for Technology/ Deanship of Graduate School and Scientific Research, Amman, Jordan

² RWTH Aachen University, Center for Learning and Knowledge Management & Institute of Information Management in Mechanical Engineering (ZLW/IMA), Aachen, Germany

³ Technische Universität Berlin/Center for Multimedia in Education and Research, Berlin, Germany

Abstract— In this paper, we examine the development of mobile learning into the rapidly changing teaching and learning environment in Jordan in order to provide a meaningful direction for the future development of Engineering Education in Jordan. A number of applications that may contribute to the establishment of mobile learning in educational institutions were investigated and expectations concerning the impact of mobile technologies on teaching and learning were explored.

Index Terms— Mobile Learning, Engineering Education, Remote Labs.

I. INTRODUCTION

There has been a considerable investment in higher education in the Middle East, as indicated by the high admission rates to universities, being the highest in the world, and as motivated by large-scale changes within the global economic system. The present trend, thrive and expansion in education actually coincides with the persisting need to improve the quality of programs in offer and is coupled with the rapid growth of the emerging ICT technologies. The region has recently witnessed a constant growing rate on the implementation of technology-enhanced learning tools and internet online access. This may set the stage for mLearning deployment on a large scale and to increase its market share at an expected average growth rate of 32% by the year 2008 [1].

In Jordan, the rate of wireless Internet connections is increasing constantly and is likely to be a decisive factor in the development and promotion of mobile learning. In addition, new types of wireless communication services will be widely available soon, such as WiMax, which combines broadcasting with digital communication. Furthermore, technological development in mobile semiconductors such as flash memory will make mobile devices smaller, more capacious, and highly powered. Mobile content will also be easily available and plentiful as wireless Internet services are becoming popular.

In this paper, the development of mobile learning into the rapidly changing teaching and learning environment in Jordan is examined. The benefits of mobile learning will also be explored along with the challenges Jordan could face with the implementation of mobile learning [2]. The content of an electromagnetic engineering course was developed for delivery by mLearning means, based on the standard ADDIE [3] instruction design methodology. A prototype e-content module was deployed and delivered on CD-ROM, desktop and mobile learning environments. The result of an online questionnaire evaluation shows

that a mobile education system will be a good complement to existing desktop systems as it brings convenience to most students and professors. The price of using mobile devices and networks is still a decisive factor, which will certainly influence the popularity of future mobile education systems.

II. TECHNOLOGY-ENHANCED MOBILE LEARNING

In recent years, a significant number of people have transformed mobile communication devices into personal assistance tools with the ability to access e-mail, search the World Wide Web, read the news, access documents, and organize calendars [4]. The new features and functionalities of handheld devices such as streaming video, color-display screens, Internet browsers, compatibility with desktop applications, and the improved connectivity capabilities have paved the way for mobile devices to support learning activities and to open the door to be the most suitable choice as a learning environment. As such, the talking function of handheld devices is no longer its dominant function and textual and visual communications as well as uses of web resources and applications are fast becoming central functions of modern mobile communication [4].

Mobile learning is thus defined as the delivery of online electronic content by means of emerging technologies [5-7]. It has indeed become an innovative means to deliver content and to embed technology into university education because it allows educators to interact with students and to provide input into the design of mobile technology which itself is becoming affordable. However, mobile learning is not intended to replace traditional classroom instruction and lectures or to convert all PC-based learning content into a mobile format, but rather to consider how mobile devices can be used to enhance the learning experience and to strengthen and harmonize its overall strategy. Consequently, universities worldwide are utilizing such mechanisms to improve their curriculum design in a way as to integrate more flexible, accessible and personalized learning activities. The productivity and effectiveness of learners may therefore be enhanced as they will be kept engaged in ongoing learning activities twenty-four-seven.

III. MOBILE LEARNING CONCEPT

Recent development in mobile technology has provided a new way to exchange information for education purposes where both learners and the teachers can access information sources anytime and anywhere. Mobile education is defined as "any service or facility that supplies a learner with general electronic information and educational content that aids in acquisition of knowledge

regardless of location and time” [8]. There are three ways in which learning can be considered mobile. First, learning is mobile in terms of space. Second, it is mobile in different areas of life. And third, it is mobile with respect to time” [Chen]. A mobile education system should therefore be capable of delivering education content the learner needs anytime and anywhere. The learner can be a full time internal, extramural, or even an overseas student, who can get all necessary educational information with the mobile device in hand as convenient as in the traditional learning environment.

As a new way of knowledge acquisition, mobile learning should adopt its own pattern or model with its own characteristics that include urgency of learning need; initiative of knowledge acquisition; mobility of learning setting; interactivity of learning process; situating of instructional activities and integration of instructional content [9]. A highly interactive environment is first designed and then integrated with one pedagogical model [10]. This approach classifies technology-embedded classroom interactions into four categories: face-to-face interaction; computer-mediated interaction; human-computer interaction; and personal device supported simultaneous group interaction. The proposed model is used when students are assigned narrative materials to read and listen. Its central idea is to give each team a unique topic to learn together and each team member a subtopic, instead of having all teams study the same material. It is based on the idea that “Learning activities are complex systems of interactions, and the benefits of ubiquity and mobility (of wireless technology) can be easily lost if that complexity is not appreciated and understood” [11].

This particular design integrates the advantages of the four types of interaction and thus can benefit students by allowing them to experience real-time or anytime learning and to interact with each other either in the virtual classroom (in the Internet) or physical classroom (face-to-face) [12]. The above are models and principles that should all be taken into consideration when designing mobile education systems.

What the mobile learners need is information about the university, courses, help topics and personal details including academic, financial, contact information and library record. The mobile learners also prefer to post classified ads, ask question, and borrow books. Our mobile system should include modules as News, Classified Ads, Academic, Financial, Library, Account and Help. The mobile learners can log in the system and the system will present personalized information to learners respectively. If a learner doesn't log in the system, he can browse part of the information available on the system.

IV. INSTRUCTIONAL DESIGN METHODOLOGY

The course module was designed based on the standard ADDIE [3] instruction design methodology where for each lesson the five phases of analysis, design, development, implementation and evaluation are followed. During the analysis phase, several work sessions had been conducted between the subject matter expert and the instructional designer to cover needs analysis, target audience, technology issues and current infrastructure for deployment, learning objectives and instructional goals, content analysis and project time plan.



Figure 1. The four sub-screens developed for Coulomb's Law lesson.

In the design phase, a complete storyboard was developed. The lesson was demonstrated through six screens where the student can switch seamlessly from one screen to another through a graphical colorful interface. The screens developed depend on the nature of the lecture. In our example, a Coulomb's Law lesson; four sub-screens were created to include a biography of Coulomb, an interactive activity that describes the theory, and the exact text of the law and its step-by-step derivation of the problem, as shown in Fig. 1 a-d. This was created as paper to allow easy navigation and hard copy printing. Each key figure was preceded by informative content which was facilitated through a pause process provided to the learner.

For this lecture, the SME had advised that it was important for the students to know the application of the electrostatic in real life. Consequently, a group of industries were recognized as medium for applying electrostatics including electronics, computer peripherals, medicine, industrial equipments, and agriculture. For each field a group of photos were gathered and ran through some digital processing to make them suitable for the prototype needed in all its versions: desktop, web and the mobile. An iconic representation for each application field was displayed and once the student clicks on it, a slideshow of related pictures is displayed.

The first application of Coulomb's law was illustrated through an example of finding the electric field at a general point due to a of uniformly distributed line charge. A simulation screen was made for students to show how to obtain the electric field force and intensity on a point charge following a set of equations, which were related in a step-by-step walk through method to find the final formula with the vector drawing and calculus. The explanation for each step was recorded and displayed as accompanied narration to the activity. The student had the full control of this activity through the "control tracker" that has a play/pause, start, end, backward and forward buttons.

The second example was given again to find the electric field due to line charge but with the line on a different point on the z-axis while the third example dealt with a ring of charge. Although Gauss's law is not a key figure related to the subject of the module, its application in some relevant cases is presented, including biography and a step-by-step examples.

Upon completing the above development, a cycle of Flash Action-script code optimization was conducted to come out with two versions; web and mobile. This came as part of Implementation and deployment phases. The development phase was quite interesting as it had to consider the final product for the three delivery channels in a CD-ROM, web and mobile devices (cf. Fig. 2 a-d). The main technology used was Adobe Flash. For the desktop version, a video introduction for instructors was added to give a brief about the project and the module the students will use. A live video shooting was taken in one of the actual classes. The video was then displayed in the introduction using all target devices including desktop, laptop, mobile phone, i-mate and iPod in order to emphasize the mobility of the proposed e-learning module.



Figure 2. Mobile Learning Environments.

V. IMPLEMENTATIONS

We have implemented a mobile and a version. Both are described in the following subchapters.

A. Mobile Version

A number of technical actions steps were taken to produce the mobile version using Flash Lite [13]. First, the graphics were optimized in files, the Flash Lite version supported by the mobile device was identifying and then the flash files were published with Flash Lite player. Finally, the files were programmed to match the Flash Lite player. The main problem that was encountered was to change the flash stage dimensions to comply with the specifications of the various screens of the mobile devices. The number of pixels suitable for each device has to be predetermined, for example 176×208 pixels were used for certain devices while 240×320, 352×416 and 320×240 pixels were suitable for others. The emulator for a given device was used to test for the best choice of pixels, and finally testing it on the corresponding mobile device itself as shown in Fig. 3 below.

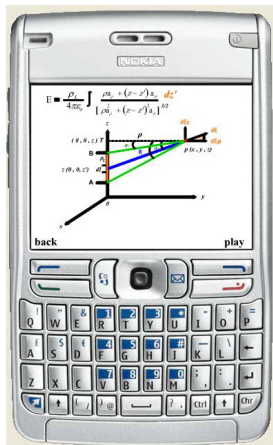


Figure 3. Smartphone Emulator from NI LabView

B. Web Version (SCORM under Moodle)

In coordination with PSUT, the decision was to select Moodle LMS as the hosting platform for our prototype. So a SCORM (Sharable Content Object Reference Model) version was created from the Desktop version. An inexpensive commercial tool called WBTEExpress [14] was chosen to create the SCORM package. The process also has gone through graphics optimization for bandwidth considerations.

VI. MOBILE LEARNING IMPLEMENTATION

Examples from two universities in Jordan are given in order to study the implementation of content, models and environments of mobile learning and ubiquitous computing technology in education.

A. Electromagnetic Engineering Course at PSUT

The first example is given at Princess Sumaya University for Technology, where a content of an electromagnetic engineering course was developed for delivery based on the standard ADDIE instruction design methodology. A prototype e-content module was deployed and delivered through mobile learning environments as shown in Fig. 2. A cycle of Adobe Flash action-script code optimization was conducted to come out with

two versions: web and mobile. The goal of the project was to investigate the possibility of providing individual faculty members with technology-enhanced learning tools to assist them in their educational mission [15].

B. Interactive Web-based Quiz at Arac Academy for Banking and Financial Sciences

The second example was the design of a mobile quiz system at the Arab Academy for Banking and Financial Sciences. The system was deployed on a PDA to enable instructors to create interactive Web-based quizzes, which can be delivered to an Internet-connected computer equipped with a browser [16]. Students can access and perform quizzes anywhere anytime using the PDAs as shown in Fig. 3. The objective of this examination system was to offer students the benefits provided by mobile learning based on its natural characteristics: mobility, portability, and individualization. Additional benefits include interactivity of the learning process, integration of instructional content and urgency of learning needs.

C. Mobile Virtual Laboratory at PSUT

The third example is a mobile virtual laboratory developed, at Princess Sumaya University for Technology, to help students perform virtual experiments using mobile devices as shown in Fig. 4 below.



Figure 4. Different Channels for Virtual Experiments

The project was carried out in order to share resources and equipment which can be integrated in an environment created using mobile devices via the Internet and the GPRS telecommunication networks. Java wireless communication technologies were used in the design and a similar design is being implemented using LabVIEW software as shown in Fig. 4. In all these examples, the mobile content was designed and developed for limited bandwidth connections, which can be delivered through wireless communication networks.

The mobile virtual laboratory provides appropriate evidence that mobile learning can be successfully utilized with the integration of learning resources, wireless networking capability and real time data acquisition and control system. Such a challenge is being overcome through a combination of mobile communication networks, handheld devices, interfacing technology for program download and remote control, and real time development module for learners to verify their experimental program codes. In this combination, the wireless local area network (WIFI), which provides access to the Internet, and PDA which replaces the computer for interaction between learner and learning material, are adopted. Furthermore, the web camera technology is proposed to simultaneously monitor the execution of experiment in the remote laboratory [17].

VII. ARCHITECTURE OF THE MOBILE REMOTE LAB

An effective way of improving technology-enhanced engineering education is to combine theory and practice simultaneously in the same lesson. This may be achieved utilizing the graphical interface capability and web publishing facility of LabVIEW. In addition, a lesson may consist of text, figures and circuits and necessitates the use of multi-screens design. This requires the program to navigate from one page to another due to the limited capacity of the screen. Several methods have been implemented to manage this situation, including the use of hyperlinks and buttons, as well as the attempt to interface LabVIEW with other programming languages such as Java. The use of tab pages has however been found the most suitable and convenient solution to navigate between pages in this particular application.

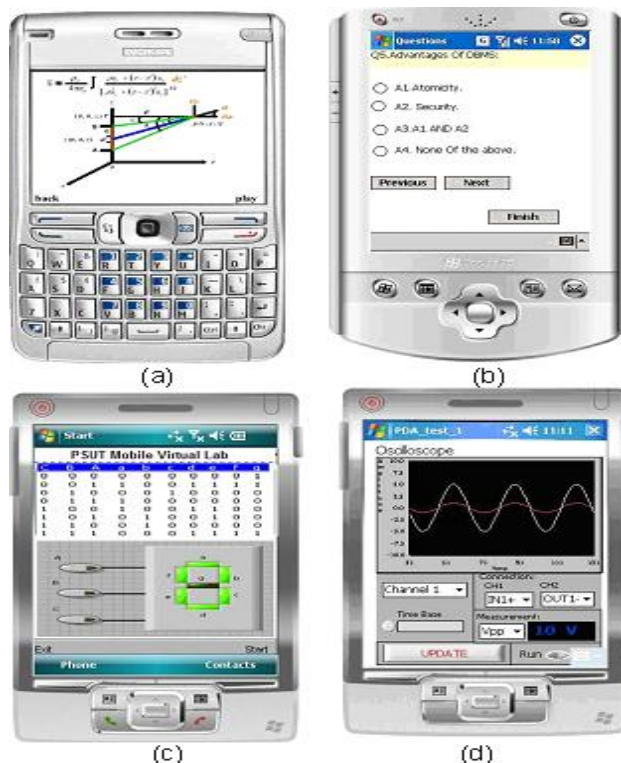


Figure 5. Examples of Mobile Learning in University Education in Jordan.

The application of interest here is to enable electrical engineering students to revise material anywhere at anytime. The material may be in the form of text, equations, figures, intimations, and circuits. However, it is also important for students to conduct experimental work virtually by simulation or remotely by accessing laboratory set-ups through the internet.

The most popular environment to implement virtual and remote experimentations is the Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) programming language, which has been extensively used for such purpose [1, 17]. LabVIEW is high-level, user-friendly, graphical programming language developed by National Instruments (NI) for use by scientists and engineers, particularly for data processing and acquisitions applications. LabVIEW employs special controls to form instructions and icons to build subroutines, wired together in order to define the flow of data through the program. In

this context, LabVIEW is a visual language and not text-based where the code is governed by a series of rules based syntax such as commas, periods, semicolons, and several types of brackets. To the contrary, LabVIEW flowcharts the code as it is written to produce a program in a timely and efficient manner. This programming approach is based on building blocks called Virtual Instruments (VIs); each contains three main parts: front panel; block diagram; and icon/connector. The front panel is a means of interaction between the user and the block diagram (program) when the program is running. Users may utilize the front panel to control the program, alter inputs, and monitor changes, updates and other variations in real time. Indicators are program outputs used to display the status of program variables, parameters, flags or other types of data, states, and other information. Front panel objects appear as terminals on the block diagram where every control and indicator has a corresponding terminal, which contains the graphical source code. Additionally, certain functions and structures which reside in built-in LabVIEW VI libraries are used in the block diagram.

A special LabVIEW add-on module has also been devised to allow one to run LabVIEW virtual instruments (VIs) on PDA execution targets. The module is a good tool for creating data acquisition and remote system monitoring applications that are both portable and flexible. The LabVIEW PDA module is usually operated with an emulator that can be used to test the application inside a simulated environment to mimic the behavior of the actual PDA. It gives additional flexibility in the design and testing and establishes greater confidence that the applications will behave as intended, and hence the lesson is tested prior to loading into the actual PDA. It facilitates the development of graphical environment to create custom applications for a multitude of mobile devices and PDAs. The programmer is therefore given the choice to select of the appropriate operating system that will be implemented in the design before commencing with writing the program.

The system was modified further into the architecture shown in Fig.6 to perform remote real electronic experiments via the internet. This architecture shows the methodology of how remote clients will connect to the remote lab. The user interface and the control of the lab hardware were developed with LabVIEW virtual instruments to design front panels, which resemble the front view of a real oscilloscope and a function generator, for example, and to have nearly the same functionalities as real devices. These VIs were then embedded into HTML and published in the Web server, which also hosts the READ laboratory home page with information about the implemented exercises, as well as the links to system login. The front panels could then be remotely reached via a standard Web browser, which does not require of the user any prior knowledge of LabVIEW to take advantage of the system facilities.

Students may be able to enter READ and carry out analog electronics experiments from anywhere at anytime by simply modifying the system layout to include access via wireless devices as shown in the architecture of Fig. 5. The proposed approach is to implement a client PDA which may communicate with the Web and VI servers directly with transmission control protocol (TCP), internet protocol (IP), or user datagram protocol (UDP), being the

basic standard protocols for network communications and data transfer through the internet.

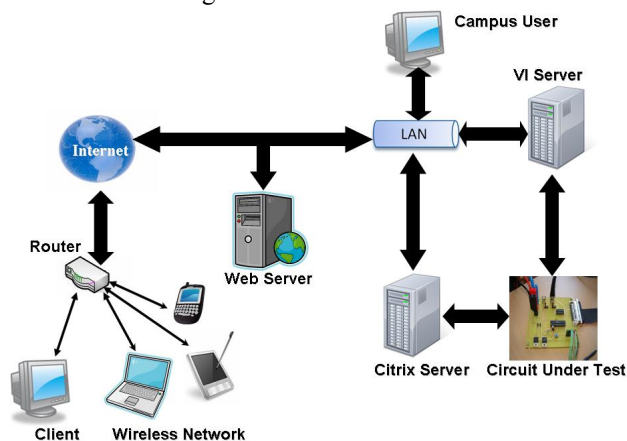


Figure 6. Mobile Remote Laboratory Architecture.

Each client connected has the requests processed during its time slice. While a client is connected, it is occupying a position in the queue and is consuming resources. Therefore, maximum connection duration of 30 minutes was allowed. The server processes client requests by applying the desired signal to the circuit under test and returns the measurements according to the simple process shown in Fig. 6.

Clients were designed for PDAs as well as for Windows PCs and requests from both were treated seamlessly by the server. Due to resources constraints of PDA devices, not all the features designed for a client running on a PC are performed when accessing the system via PDAs, but this can be managed just by changing the client application. A simple experiment to generate a number of waveforms with varying amplitudes, frequencies and shapes was actually performed remotely on a PDA as shown in Fig. 7 to control and simulate an actual function generator. The most important consideration, however, was the limited resources of mobile devices compared to PCs which lead to a reduction of the features available for designing mobile remote laboratory. Nonetheless, the proposed solutions remain applicable to a number of experiments where initial results have been encouraging as students able to undertake simple engineering remote tasks. Further experiments are being prepared.

VIII. SUGGESTIONS DEVELOPED

Mobile learning needs to break the barriers in learning, perhaps for individuals who were previously not able to access education due to disabilities, or economic circumstances, as we have many of them in the Arab world. Only then, will mobile learning become a significant technology in today's technologically-added world. It is therefore suggested

- (1) that the course content, illustrations and design should be tailor-made, and enriched with multimedia capabilities, to suit the mobile device used;
- (2) Studying with mobile devices should only be used for short-period courses, and one should start with simple knowledge courses that everyone needs to know like English language and computing basics. In addition, a free learning program for testing whether this new way of learning is worthwhile pursuing and made

applicable. And, a back-up and maintenance systems should be reliable and efficient;

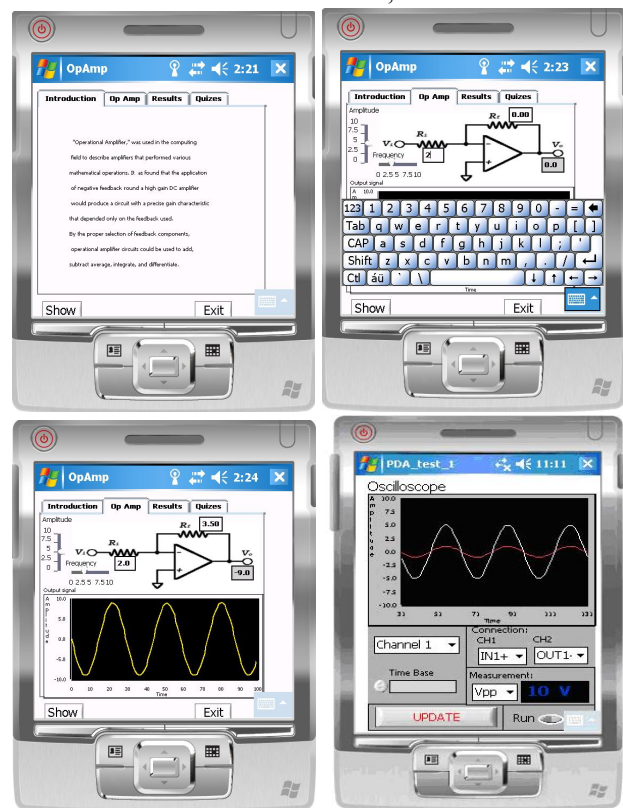


Figure 7. Introduction to the topic (top left), circuit displays (top right and bottom left, experimental results (bottom right)

- (3) Mobile learning should have network accessibility like WiMax and be categorized into at least 2 segments, first via paid cellular service, and second through 'free' internet. We also need to upgrade and develop the infrastructure and facilities before mobile learning can be fully implemented;
- (4) Privacy and security measures, grades for example, must be taken into account, just in case not to be altered by a third party;
- (5) A campaign is needed to promote mobile learning.

It is evident that the results reflect the fact that mobile learning still faces several challenges for its future development in eEducation despite its application in various fields. Issues related to the convergence of wireless infrastructure with handheld devices, the smoother delivery of learning content, and the innovations in content creation are the main challenges that need to be addressed and resolved. In addition, theoretical and practical guidelines should be devised to enable professors, instructional designers, programmers, and education administrators to develop proper mobile learning content and curricula. This will contribute to constructing a better environment for learning and a more educated society in the near future.

The findings of this survey thus reveal some discouraging facts for the future of mobile learning as little educational content for the wireless Internet is available, and as the overall user satisfaction rate is very low, the speed is very slow and service charges are very high. There were few requirements that must be fully met before a promising teaching and learning environments

can be added by mobile devices. Such requirements include the need to establish a learning strategy of mobile learning with a focus on the adaptive and flexible nature of the learning process, standardization of contents and the necessity to reach a consensus among educators on the validity and potential of this new method of knowledge acquisition and construction. Then can mobile learning become an accepted mode for the next generation [3].

IX. CONCLUSION

Mobile learning environments in Jordan were investigated through the implementation of a number of projects in two universities. An online survey was conducted to investigate the expectations and perceptions of mobile learning amongst university students and professors and various factors that may contribute to the establishment of mobile learning platforms in educational institutions were studied.

The results reflect on the fundamental needs for effective implementation of mobile learning from the view of cognitive science, instead of technological evolution. The findings also reveal some discouraging facts for the future of mobile learning because of the scarcity of content that can be utilized. In addition, the slow internet speed and its high service charges are two other major factors that hinder the progress of mobile learning in Jordan. However, universities are expected to develop proper mobile learning content and curricula, which will eventually contribute to creating a learning environment that will help develop further the country's educated society in the near future. The mobile devices also allowed for greater ease of lecture delivery, specifically in allowing the lecturer to import into the lecture graphic simulations and animations using on the fly internet images and computer simulations as well as power point presentations. These lectures can be saved and posted on an eLearning platform or the professor website for students' future reference.

The results of student perception and acceptance of mobile devices implementation for lecture delivery indicate that mobile devices for students should be pursued for teaching the electromagnetic course, and should be extended to other simpler courses with large audiences and with application for which the mobile devices are well-suited. The results are consistent and provide reliable pointers towards the usefulness of mobile devices for faculty at the university level. The ultimate goal of the study is to investigate the possibility to provide individual faculty members at Princess Sumaya University for Technology and at other universities in Jordan with technology-enhanced learning tools to assist them in their educational mission.

REFERENCES

- [1] B. Kleefßen, ICWE, "E-Learning in the Middle East-A Fast Growing Market", Online Educa Berlin, Berlin, Germany, 17 November 2004. http://www.global-learning.de/g-learn/cgi-bin/gl_userpage.cgi?StructuredContent=m130218
- [2] R. Yu-Liang Ting, "Mobile Learning: Current Trend and Future Challenges", Proceedings of the 5th IEEE Int. Conf. on Advanced Learning Techn. (ICALT'05), Kaohsiung, Taiwan, 5-8 July 2005.
- [3] C.-Y. Lai and W.-C. Liou, "Rapid ADDIE Curriculums Design Model Based on the Heterogeneous Multimedia Information Integration", Proceedings of the 9th IEEE International Symposium on Multimedia Workshops (ISMW 2007).
- [4] O. Zawacki-Richter, T. Brown, and R. Delpont, "Mobile Learning-a New Paradigm Shift in Distance Education?", Proc. of the 5th Int. World Conf. on Mobile Learning, Banff, Canada, 22-25.10.2006.
- [5] O. Zawacki-Richter, T. Brown and, R. Delpont, "Factors that May Contribute to the Establishment of Mobile Learning in Institutions-Results from a Survey", The 2nd International Conference on Interactive Mobile and Computer Aided Learning, IMCL2007, Amman, Jordan, April 18 -20, 2007.
- [6] T. Rahim Soomro, M. Nawaz Brohi, and S. Mehmood Naqvi, "Technological Trends of Distance Learning: From Web-Based to WAP-Based", The Western Canadian Conference on Computing Education, WCCCE2005, Prince George, Northern British Columbia, Canada, 5-6 May 2005.
- [7] A.Y. Al-Zoubi and A. Attiat, "Development of eContent for Delivery of an Undergraduate Electromagnetic Course Using Mobile Devices", 4th Annual Conf. of MIT Learning International Networks Consortium, LINC2007, 28-30 October 2007, Jordan.
- [8] J. Chen and J. Kinshuk, "Mobile technology in educational services", J Educational Multimedia and Hypermedia, 2005, vol./is. 14/1(91-109), 1055-8896;1943-5916 (2005).
- [9] S. Yahya, E. Arniza Ahmad, and K. Abd Jalil, "The definition and characteristics of ubiquitous learning: A discussion", International Journal of Education and Development using Information and Communication Technology (IJEDICT), Vol. 6, Issue 1 (2010).
- [10] T-C. Liu, H-Y. Wang, J-K. Liang, T-W. Chan, and J-C. Yang, "Applying Wireless Technologies to Build a Highly Interactive Environment", Proceedings of the IEEE Workshop on Wireless and Mobile Technologies (WMTE'02) (2002).
- [11] G. Gay, "Activity-Centered Design: An Ecological Approach to Designing Smart Tools and Usable Systems (Acting with Technology)", The MIT Press (2004).
- [12] iLearn, last access 1.4.2010 ilearn.lst.ncu.edu.tw/itlab/mediawiki/index.php/Discuss1012_3
- [13] Adobe Flash Lite, , last access 1.4.2010 <http://www.adobe.com/products/flashlite/>
- [14] 4System, The Art of eLearning, WBExpress 7.0, last access 1.4.2010, <http://www.wbexpress.com/>
- [15] M. Otair, A. Tawfiq, A.Y. Al-Zoubi, and A. Alkouz, "A Mobile Quiz System for Assessment of the Learning Process", paper submitted for presentation in the 3rd International Conference on Interactive Mobile and Computer Aided Learning, IMCL2008, 16-18 April 2008, Amman, Jordan.
- [16] A.Y. Al-Zoubi, S. Jeschke, N. Natho, O. Pfeiffer, and J. Nsour, "Integration of an Online Digital Logic Design Lab for IT Education," In: Proc. of the 2008 ACM Information Technology Education Conf. ACM, pp. 237-241. (2008).
- [17] A.Y. Al-Zoubi, B. Kahhaleh, O. Hasan, and H. Kharouf, "Future Potential of ICT Implementation in University eEducation in Jordan", 10th Int. Conference on Interactive Computer Aided Learning, ICL2007, Villach, Austria, September 26-28, 2007.

AUTHORS

Prof. Dr. A.Y. Al-Zoubi is with the Princess Sumaya University for Technology (PSUT), Khalil Saket Street, P. O. Box 1438, Al-Jubaiha 11941, Amman, Jordan (e-mail: zoubi@psut.edu.jo).

Prof. Dr. rer. nat. Sabina Jeschke is head of the Center for Learning and Knowledge Management and Institute of Information Management in Mechanical Engineering (ZLW/IMA), RWTH Aachen University, Aachen, Germany, Dennewartstraße 27, 52068 Aachen (e-mail: sabina.jeschke@zlw-ima.rwth-aachen.de).

Dipl. Math. Olivier Pfeiffer is researcher at the Institute of Mathematics at the School of Mathematics and Natural Sciences, Technische Universität Berlin, Germany, Straße des 17. Juni 136, 10623 Berlin (e-mail: pfeiffer@math.tu-berlin.de).

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